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DATA ON METAL-MINE VENTILATION IN 1929

BY

D. HARRINGTON

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DEPARTMENT OF COMMERCE - BUREAU OF MINES

DATA ON METAL-MINE VENTILATION IN 1929[1]

By D. Harrington[2]

The year 1929 was chiefly one of progress as concerns the various factors affecting and being affected by ventilation in metal mines. As with all phases of health, safety, and efficiency in mining, however, not everything has been done which should be done, and by no means has perfection been reached in anything in connection with the ventilation of metal mines. One of the most noteworthy causes for congratulation is the fact that although a number of fires occurred in metal mines there was little or no loss of life in these affairs as far as can be learned. Numerous occurrences or conditions were brought to light during the year concerning factors entering into ventilation of metal mines, such as occurrence of gases in metal mines; effect of blasting on the air in mines; metal-mine fires, their occurrence and causes, and methods of prevention or of handling them; air conditioning; health of metal miners as affected by ventilation; up-to-date methods of forwarding and controlling air flow in metal mines; published data during the year relating to metal mining, etc.

GASES FOUND IN METAL MINES

As usual there were some ignitions of methane in metal mines or in tunnels; at least two ignitions of methane, fortunately with no fatalities occurred in the Hetch Hetchy Tunnels near San Francisco. In the 1928 report of the State Inspection Force of Kansas, published in the spring of 1929, appeared the following interesting description of a metal-mine explosion of methane with resultant loss of two lives:

> On July 16, 1928, a call came to the rescue department at Pittsburgh at about 3:50 p.m., advising that an explosion had occurred at a lead and zinc mine operated by the Cunningham Mining Co., located near Pleasanton, Kans. The explosion occurred about 2:30 p.m., and there were four men in the mine at that time, two of the number, namely, William Cunningham, owner, and Jack Howards were brought to the surface a few minutes after the explosion. The other two men were still in the mine.
>
> Mr. James Sherwood, State mine inspector, and George J. Gruber, clerk, proceeded to the mine in Mr. Sherwood's car. Mr. Hislop, superintendent of the central station, and Ernest Shaw,

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1 - Report of chairman of the subcommittee on Metal Mine Ventilation of the American Institute of Mining and Metallurgical Engineers, presented at the New York meeting on February 19, 1930. The Bureau of Mines will welcome reprinting of this paper, provided the following footnote acknowledgment is used: "Reprinted from U. S. Bureau of Mines Information Circular 6246.

2 - Chief engineer, safety division, U. S. Bureau of Mines.

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deputy mine inspector, and Mr. Glennon, deputy mine inspector, proceeded to the mine in the central rescue car. After driving as far as Arma, Kans., Mr. Glennon joined William Beveridge, superintendent of Arma station, in the Arma rescue car, and then the entire crew proceeded to the lead mine, which was a distance of 67 miles from Pittsburg. After driving two hours and five minutes we arrived at the mine, and were informed that Hugh Cunningham was hoisted up about 40 feet from the bottom of the mine, when he fell out of the bucket to the bottom of the mine. An employee of the mine went down and brought Mr. Cunningham to the surface. Mr. Cunningham received a fracture of the leg and forearm in his fall. He was immediately taken to a hospital, where he died a few hours later. Harold Cole was the only man in the mine when we arrived. At this time the gas was too dangerous to enter the mine, we were unable to descend with our apparatus on account of timbers and rubbish being strewn about the shaft, making it impassable. A canvas tube had been devised and after the fan had been run about an hour several men attempted to explore the mine. One of the number, Mr. Beveridge of the Arma rescue station, went to the bottom of the mine, and a few minutes later was again brought to the surface. He said that the mine was badly caving and pushing the cribbing and pump at the bottom of the mine to one side. He said it was unsafe to touch anything, as the mine was liable to cave any minute. Instructions were given to have all the rubbish cleaned out of the shaft, and attempts would then be made to find the body, as the mine was free of gas by this time. The essential thing to be done now was to clear the shaft of timber, etc., so that workmen could remove some of the rubbish at the bottom of the mine. This was partly accomplished and the water was pumped from the sump, and then a party of the rescue crew went to the bottom of the mine and found the body in the sump, where it had been lying under 4 feet of water. Harold Cole's body was brought to the surface at about 5 a.m., July 17, 1928.

This mine had not been operating very long when they broke into some old workings, from which the gas came. The miners used electric lamps, which were of the battery type. One of the men who was brought up alive said that he saw a rock fall and strike an electric lamp and then the explosion occurred. This mine was in a terrible condition and should have never been allowed to operate."

In an underground limestone mine in one of the Central States a ventilation survey disclosed that not only were there appreciable percentages of methane present in the air in which the work was being done, but there was also sufficient carbon monoxide to give the workers headaches and possibly under some conditions to produce more harmful effects; the methane probably comes from some carbonaceous shales which are present, and the carbon monoxide is due to the use of ordinary gasoline-operated trucks for transporting the limestone underground through some tunnels. While the occurrence of carbon monoxide underground from gasoline-operated trucks is novel, the occurrence of carbon monoxide in mine air from

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gasoline-driven locomotives is not as novel as it should be, as a number of gasoline locomotives are operated in metal mines - a dangerous practice which should not be countenanced even when all available precautions are employed.

Every year brings forth some fatalities due to CO_2, or attendant oxygen deficiency, in metal mines, and 1929 was no exception; the following paragraph from the Engineering and Mining Journal, issue of April 6, 1929, describes a typical accident where due care is not exercised in going into abandoned mines or parts of mines:

> "At the Monarch-Rand property, in the Randsburg district of California, E. C. Marshall, superintendent of the mine, and J. A. Marshall, his brother, were fatally gassed on March 25, 1929. The property had been shut down for a considerable period, and the two brothers entered the mine, being lowered in the shaft. It is assumed that they were overcome by the gas and were unable to signal to the surface. A rescue party entered the shaft, but encountered bad air at the 600 level and was forced to return. After five hours the mine was sufficiently cleared to enable another party to reach the bodies of the Marshall brothers."

Since no year passes without the occurrence of fatalities when unsuspecting foolish people, and some times this includes mine officials, enter abandoned mine openings without exercising sufficient precautions, it would appear that not only abandoned mines but abandoned parts of operating mines should be kept effectively sealed. The following excerpt from The Black Diamond, August 10, 1929, indicates that this problem confronts not only metal but coal mines:

> "That old coal mines which have been abandoned should be sealed up, has been shown on several occasions in eastern Kentucky. Skeletons were found in an abandoned mine last year, indicating foul play, one being that of a girl about 16 to 17 years of age. Just recently two boys, 15 and 17 years of age, were found dead about 75 feet back in a deserted mine in the Hazard field, they having been overcome with bad air. Efforts of the district mine inspection department to revive the boys were without result. Both boys were high school students. They had gone to the mine with a horse and wagon for a load of coal, which was available for the taking. Even they might be crushed, through careless pulling of pillars. All of this surely bespeaks attention on the part of the authorities. An abandoned mine is a standing menace to a community, offering as it does infinite temptations to the criminal and infinite dangers to the careless. This matter is worthy of agitation until it is firmly fixed in the public mind."

A novel occurrence of CO_2 is described in The Colliery Guardian, issue of December 14, 1928, as follows:

> In a recent number of Montanistische Rundschau, an Austrian Mining Engineer, H. Drotz, gives an account of the serious disturbance to sinking operations caused by irruptions of carbon dioxide gas. The surface ground in the

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Ostrau-Karwin region (Moravia), where the two shafts - winding and ventilation - were sunk, consists of loam, sand and gravel, followed by the Eocene clay, which reaches down to the cap rock of the coal. In the lower sections and strata of the rock are interbedded Tertiary sand and grit. It was in the shifting sand at a lower level that the trouble was experienced with the irruptions of CO_2. After successive operations had been carried out extending over a period of eight years - from 1900 to 1908 - the shafts had finally to be abandoned and other ones sunk in the vicinity, away from the seat of the trouble. The sinking operations included ordinary sinking and, later, when the trouble became too serious to cope with, the Kind-Chaudron; while various methods were utilized for dealing with the water, including the use of compressed-air pumps and draining off the water by large-capacity buckets drawn to the surface by winding engines. The irruptions of CO_2 proceeded at intervals, frequently assuming a most violent form and causing serious damage to the then existing lining of the shaft, besides rendering the sinking and pumping operations difficult and dangerous owing to the risk of suffocation involved. Discussing the possible cause of the continued presence of the CO_2, the present writer ventures the opinion that it probably accumulated in a deep cavity in the rock and, owing to the superincumbent clay above, it could not find an outlet, so that it remained, at high pressure, in the cavity, which was exposed when this particular portion of the strata was uncovered by drilling operations."

During the year 1929, as well as in previous years, a gas carrying the odor of both H_2S and SO_2 occurred in a winze of a gold-silver property in the Rico-Colorado district. The analysis of one sample showed practically 50 per cent CO_2, about 10 per cent oxygen, and about 40 per cent nitrogen, the SO_2 and H_2S were not determined because of inability to analyze the gas immediately upon sampling and the fact that when analysis of samples with relatively small proportions of sulphur gases must be delayed, these gases break down. Here the gases were undoubtedly due to rapid oxidation of a granular pyrite, as there were locally high air temperatures (around or in excess of 100°F.) where the gas was at its densest.

In connection with some preliminary work being done in starting tunnels for the city of Detroit, two men lost their lives because of an occurrence of H_2S gas in a shallow shaft. During the past few years there have been a number of occurrences of methane, H_2S, CO_2, and other gases in the driving of tunnels for city water or similar service in various parts of the country, and it would appear that tunnel driving should be given more careful technical inspection and supervision.

During the year there has been a continuation of spontaneous fires in black slates in some Minnesota mines; the fumes have an odor of SO_2 and H_2S and also contain CO. Special methods of ventilation must be used in these places, and it is probable that ultimately an attempt must be made to put the region of the

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fire and the adjacent territory under ventilating pressure in order, if possible, to force the gases into the strata more or less broken by mining.

In The National Safety News of September, 1928, there was an interesting article concerning H_2S and its treatment and effect as portrayed by a doctor who had treated more than 300 persons suffering from exposure to the gas. Below are salient paragraphs from this article:

Hydrogen sulphide gas attacks the mucous membranes of the body; the coverings of the eye, lining of the nose, throat, lungs, stomach, intestinal tract and urethra, all of which are protective. The mucous membrane may be either irritated or destroyed in varying degrees, regenerating, as a rule, within 48 to 72 hours.

The eye has nine coats, of which the mucous membrane is the outer, or protective, and the optic nerve with which we see is the inner. Hence the blurred vision when the mucous membrane is destroyed as light does not pass through normally, but no damage is done to the nerve layer. The danger in this state is infection from the outside, as from dirt, oil, etc., from the face of hands by rubbing. This infection might cause an ulcer to form and endanger the sight of the eye, as an ulcer from any other cause would do unless proper medical care is given.

Treatment for the Eye

Hydrogen sulphide gas, when it comes in contact with the eye, forms small amounts of sulphurous acid, which should be washed from the eye with boric acid solution, following with the neosilvol, 10 per cent and butyn solution 2 per cent every half hour or more often as the case needs, keeping either ice packs or hot towels over the patient's eyes and respiratory tract. Rest and sleep in a dark room is highly important. In very severe cases, atropine sulphate 1 per cent should be used and, if desired, small amounts of cocaine may be added to the solution of neosilvol butyn to ease the burning pain. The eyes should be covered and protected from the sunlight for 24 to 72 hours, as the case may require.

When the mucous membrane of the lungs is irritated or destroyed the patient should be protected from exposure to cold as pneumonia or other infections can easily gain a foothold while the mucous membrane or outside protective sentinel is being regenerated. The same is true of the stomach and intestinal tract. Nothing should be given by mouth except water as the stomach is or may very easily become irritated and cramping, nausea and vomiting instituted. In more severe cases, absolutely nothing should be given by mouth; even water will bring on relapses, cramping, and distress.

When a great concentration of gas is encountered, nature, ever on guard to save life, stops respiration; the respiratory center of the

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brain is paralyzed, which stops the intake of the methane and higher gases into the lungs and, hence, into the bloodstream. The bloodstream itself is the part of the body affected by this heavy dose. If the patient runs to fresh air and respiration starts again of its own accord, or, if artificial respiration is instituted, the poison from the blood is eliminated through the lungs and kidneys, the latter evidenced by a burning sensation upon urination.

Resuscitation Saves Many

'Artificial respiration plays a big part in reviving men who have had a lethal dose of the gas. A worker was gassed last April and was "out" for two hours and fifteen minutes before any sign of breathing could be seen. He was kept warm, given a stimulant, and artificial respiration was admirably given by the men and nurse on the lease. Two hours and fifteen minutes is a long time to be dead physiologically but this man within four days returned to work. His color and general health gradually improved so that he was in good condition physically within two months. While resuscitation efforts in a few cases have been of no avail, the majority of such patients have been successfully revived within a few minutes to three hours.

It is inadvisable for one with an impaired sense of smell to work around the gas. For instance, one worker was gassed severely four times. Due to absolute blockage of the nasal passages, he was unable to smell the gas and walked blindly into it. He had had his nose operated upon and has not been gassed since.

Focal Infections Add Danger

It has further been observed by me, and by many other doctors with whom I am accquainted, that men with focal infections, such as pyorrhea, decayed and infected teeth, or very bad tonsils are much more susceptible to gas attack--eyes included--than men in good condition. Of course, this is only common sense and explains why we treat the same group of men nearly all the time, while others in the same gang seldom, if ever, are gassed. Therefore, it has been our conclusion that men with focal infections should, out of justice to themselves, have these cleared up before going to work where they might encounter high concentrations of gas. Any man on a tubing job or clean-out string is likely to have his eyes gassed and should, therefore, be in perfect physical condition at all times.

'Some are under the impression that tuberculosis, typhoid and other diseases are caused by gas. It is my opinion that gas might help kindle a latent or slumbering case of tuberculosis, as will cold, exposure, bad food, and poor nourishment, but it is not apt to do so. As there are no tuberculosis germs floating in the gas and one must necessarily have them in his system before tuberculosis can exist, gas could no more cause tuberculosis than it could cause gonorrhea, trench-mouth, or any other infectious diseases caused by bacteria.

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FUMES FROM BLASTING

In connection with this matter of gases which may be encountered in metal mines, it should be borne in mind that practically every metal mine may at any time be confronted with essentially the same kind of deadly gases which caused the large number of fatalities in the Cleveland Clinic fire of May, 1929. The gases from the burning X-ray films were high concentrations of carbon monoxide mixed with heavy concentrations of various oxides of nitrogen, probably with heavy depletion of oxygen; these gases are almost sure to be found in the fumes of 20, 30, 40, 60 or 80 per cent dynamite such as is found stored in small or large quantities in more or less confined places in almost every metal mine and only too frequently surrounded with relatively few safeguards against fire or against unsafe distribution of fumes should a fire occur. It may be well to remember that concentrations of carbon monoxide or of dangerous oxides of nitrogen are very likely to be too great to allow of the safe use of any type of gas mask, and that in addition oxygen may be dangerously low; hence, nothing but the latest and most up-to-date types of oxygen breathing apparatus should be worn as a protection against breathing these fumes.

In a metal mine employing several hundred workers on a few levels in intensive development where relatively cool rock produced cool air in the working places and there was little or no dust, the matter of ventilation was largely ignored until conditions become almost intolerable because of smoke and fumes from explosives. The general manager finally admitted that there was a dead loss of at least 25 per cent of the efficiency of the workers (all on a day-pay basis). It was then decided to install a complete ventilation system with all of the fire prevention and other features involved, such as the concreting of at least one shaft and the sinking of another shaft. The installation of the system was to cost little less than one-half million dollars.

The excellent paper on ventilation at the United Verde mine presented at the New York meeting of the American Institute of Mining and Metallurgical Engineers in February 1929, brought out the fact that much of the urge toward the installation and maintenance of the exceptionally elaborate and effective ventilation system at the United Verde was the desire to safeguard workers from the deadly fumes met in the blasting of ore high in certain sulphides. The applicability of the ventilation system at the United Verde to the safeguarding of workers from blasting fumes is given in more detail in Mr. Glaeser's paper entitled "Handling Gas Hazards at the United Verde Mine" presented at the February, 1930, meeting of the American Institute of Mining and Metallurgical Engineers in New York

Three factors in recent development of metal-mine blasting practice are of much aid in providing a safer and more healthful atmosphere for face workers The use of electrical blasting is growing rapidly in at least some metal mining districts; electrical blasting automatically eliminates much of the noxious carbon monoxide, since the burning fuse has in the older system of blasting been responsible for much of the poisonous fumes. The more widespread use of clay or other similar material in tamping blasting charges also aids materially in keeping the air of blasting faces relatively clear of fumes. Finally, many mining companies have, for reasons involving safety as well as the health of the workers, required that much if not all blasting shall be done at the end of the shift; this automatically allows time for harmful dusts to settle and for explosives fumes to be drawn off by ventilating currents.

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The Engineering and Mining Journal of March, 1929, contained the following paragraphs, indicating that one of the Ontario gold mines is using the South African "water blast" with intent apparently to remove the explosive fumes from faces after blasting; however, the water blast also has the very beneficial effect of not only settling out of the air the very fine dust due to blasting but also of converting settled dust on mine surfaces to mud, thus preventing this dust also from getting into the air:

> "At the Wright-Hargreaves mine, in Kirkland Lake, it is the practice of the machine men to blow a mixture of air and water instead of air alone, after blasting, to expel the smoke and gas. To make this possible the water line is connected to the air line near the heading, so that water may be mixed with the air as desired. The mixture is blown through a 5/16 inch hole in a cap placed over the end of the 2 inch air line. This cap is screwed on by the driller after he has spit his fuses and is about to leave the heading. Connection of water line to air line is made in the following manner: At a point some distance back from the heading a tee is inserted in the air line. Into this tee at 90° to the line is screwed a nipple, on the end of which is an ordinary valve such as that used for regulating the water on the drilling machines. From this valve runs a 5 foot length of water hose, terminating in another valve, which is connected to the water line running to the face. These two valves are kept closed except when it is desired to blow the mixture of air and water.
>
> The procedure followed by the machine man is as follows: When he finishes drilling, he turns off the air and water from his heading at the nearest junction point, after which he loads his holes and spits the fuses. Then he opens the two water valves in the connection with the air line just described (one of these is used as a check), leaves the heading, and turns on both air and water at the junction point. This arrangement requires that a pressure higher than that of the air be kept on the water line to force the water into the air line. This is accomplished by maintaining 125 pound pressure on the water line, as compared with 95 pound pressure on the air line. The difference is sufficient to permit the water line to be carried up into the stopes to blow the mixture of air and water there as well as in the headings.

Many of the metal mines of the United States could, with advantage to the health and efficiency of workers, adopt the previously described South African practice now apparently in use in some gold mines of Ontario.

METAL MINE FIRES

During 1929 there were the usual number of fires in metal mines or in tunnels, fortunately with little or no loss of life this year. These fires occurred in Michigan, Minnesota, Wisconsin, Montana, Utah, Tennessee, California, and other States. As usual the main, in fact almost the only, ignition agencies were open lights and electricity; yet there is only the most feeble of efforts apparent as yet looking toward safeguarding mines and tunnels and the workers in mines and tunnels from these dangerous agencies. In an excellent article entitled "More Light for Mine Workings" which appeared in the July 20, 1929, issue of the Engineering and Mining Journal, occur the following significant paragraphs giving at least qualified advocacy by a metal mining man of the use of miners' electric cap lamps in metal mines:

'In contrast, the newer electric cap lamp is not well known as yet among the rank and file of metal miners. Just as the carbide lamp was slow in supplanting the candle and the sunshine lamp, its use at the start being confined largely to engineering crews and foremen, so time and better knowledge will evidently be required to put the electric cap lamp "across." For safety work the electric lamp is ideal. Where explosives are being handled, or stopes are hot, or the risk of fire is great, or where the air will not support combustion, it has decided advantages. It is more elaborate and expensive than its rival, and the weight of the battery as well as the lead and belt required are disadvantages save where a man's first thought is for his safety.

'But it gives superior light. With further improvements particularly in lessening the weight of the battery, it will probably find place in metal mines at an increasing rate. What the ultimate features of this type of lamp will be, only the future can disclose.'

In view of the far greater safety as well as greater efficiency of the up-to-date miners' electric cap lamps over any type of open lights yet used in mines, it is inexplicable that all of our metal miners and about half of our coal miners persist in exposing themselves to the really desperate hazards as to fires, explosions, and accidents (from insufficient light and air vitiation) which invariably are present underground when open lights are used.

In its efforts to prevent loss of life in mine fires, such as the one which occurred in the Hollinger mine in northern Ontario in 1928, Ontario has adopted some amendments to its mining law as indicated in the following items taken from the Canadian Mining Journal of March, 1929:

The Amendment to the Mining Act of Ontario which is the result of the Hollinger enquiry has incorporated the less stringent recommendations of Justice Godson into the Act, and it is understood that a further amendment will be brought down next year which will take care of other points. The additions for this year are quite simple, and do not inflict any hardship upon operators, and as they are the outcome of the deliberations, and advice of a number of the leading engineers in charge of mines in northern Ontario, they are probably already in effect in the majority of cases. The additions are as follows:

156a. Every man employed as an underground foreman (meaning thereby one who is exclusively engaged in supervising the work of other men) shall be able to give and receive orders in the English language.

156b. The Inspector of Mines shall have the right to suspend any foreman or mine captain who is not familiar with, or does not understand, the requirements of the regulations governing the operation of mines as contained in the Mining Act.

(11) No building for thawing explosives shall be maintained in connection with any mine except with the written permission of the Inspector of Mines. The site of this building and the style of structure

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and equipment shall be subject to the approval of the inspector. The building shall be under the direction of the manager or some person authorized by him. The quantity of explosives brought into any thawing house at any one time shall not exceed the requirements of the mine for a period of 24 hours, plus the amount that it may be necessary to have thawing to maintain that supply.

(38a) All underground buildings or enclosure necessary for the housing and maintenance of machinery or equipment shall be constructed as far as practicable of fireproof material.

(38b) All fans except "Booster" fans shall be above ground and shall be reversible, and all fans and structures containing the same shall be fireproof.

(38c) Oil and grease kept underground shall be contained in suitable metal receptacles and the amount so kept shall not exceed the requirements for seven days.

(38d) There shall be a sufficient number of fire doors at every underground station where practicable so that the shaft can be completely cut off from the rest of the mine.

(38e) All inflammable refuse underground shall be removed at least once in every 24 hours, and shall be brought to the surface and there disposed of in a suitable manner.

(38f) Every shift boss and mine captain shall certify in writing to the mine manager at least once in every week, that there is no accumulation of inflammable refuse underground in the area under his supervision except as reported by him.

(38g) Suitable fire protection systems shall be installed at all underground crushers, tipples, and in dry shafts.

(38h) Every mine which has a maximum production of 100 tons of ore per day, shall be equipped with the necessary mechanical apparatus so that the stench ethyl mercaptan may be introduced into the air line as a warning signal to underground workmen.

(38i) Legible signs showing the way to emergency exits shall be posted in prominent places underground and all workmen shall be instructed as to location of auxiliary exits.

The foregoing regulations are excellent and constitute a considerable stride in advance of past practice, but it is unfortunate that they do not include a requirement covering suitably controlled mechanical ventilation.

One of the "lucky" fires of 1929 occurred in an underground explosives magazine. The fire was started either by an open light or by a cigarette or match used in lighting a cigarette, but fortunately the explosives burned instead of exploding. In connection with this affair attention is again called to the numerous hazards in the storage and use of explosives in mines; certainly open lights and smoking should not be allowed in or near any explosives magazine,

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nor should persons using explosives smoke or carry an open light while handling explosives. Since many of the far too numerous accidents from explosives in metal mines originate in some manner or other from open lights or smoking, there is no good reason why both open lights and smoking should not be excluded from all mines. It may also be advisable here to call attention again to the fact that fumes from burning explosives, especially in a confined place such as an underground magazine, are likely to have so high a concentration of deadly gases, such as carbon monoxide and various oxides of nitrogen, as well as so great a depletion of oxygen, that none of the present-day gas masks are safe to use in or around the fumes. Hence, only up-to-date oxygen breathing apparatus should be used at these fires.

At a conference on spontaneous heating and ignition held in Washington, D. C., in November, 1929, attention was called to the fact that many substances such as sawdust, timber bark, splinters, etc., hay, straw, and other materials found or likely to be found in metal mines are subject to spontaneous combustion. It was also brought out that some of these substances in heating spontaneously give off explosive gases such as carbon monoxide, methane, and hydrogen, so that explosions are likely to accompany spontaneous heating, especially in a confined, poorly ventilated place. This fact is of importance in both coal and metal mining as indicating the necessity of "good housekeeping" in the removal of various kinds of rubbish from mine workings; certainly it is dangerous to store or otherwise dispose of various kinds of combustible materials in the "gob" as is so frequently done.

The American Mining Congress Committee on the Standardization of Fire Fighting Equipment in Metal Mines has been engaged in the completion of its report for submittal to the American Standards Association, and it is probable that these particular recommendations will soon be available as a "standard."

AIR CONDITIONING

Air conditioning as applied to metal mines has been largely confined to trying to cool the air where work must be done in high temperatures. To a limited extent removal of fine dust has been aimed at, but to a much greater extent the object has been removal of fumes from explosives. In the following data concerning court decisions affecting coal mines, there is a foreshadowing of what is very likely sooner or later to confront all classes of mines, coal and metal as well as nonmetallic; and it is interesting to note that in one instance the company was held responsible for alleged harm from chilling or cold conditions underground, while in another the blame was thrown on the company for a heat condition alleged to have affected the workmen. One item came from the Bulletin of the Anthracite Bureau of Information for June 1, 1929, and reads as follows:

> "The company objected to an award of compensation allowed by a referee. The claimant is the dependent widow of Joseph Gober who died in October, 1927, after he had worked in a wet part of a mine of the company.
>
> "The miner suffered a chill after standing in the water while at work driving a breast, and later died of pneumonia. The referee found death to be due to the conditions under which he worked and awarded compensation to the widow, and the company objected that the evidence

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in the case does not prove that the deceased died as a result of accidental injury.

"On the question of whether exposure caused the fatal illness, the board found the evidence sustained the referee."

Below is a reading of the other case as taken from the Bulletin of the Anthracite Bureau of Information for July 6, 1929:

"The claimant is the widow of Frank Rucci, a miner who died last August, who was allowed compensation for herself and children. The husband on August 7, 1928, left home apparently in good health and reported for work as usual. He worked all day, although he complained of pain in his head. When he returned home he complained of illness. Less than a week later he died.

"The day that he was taken ill was extremely hot, and the board, in discussing the evidence, held that 'heat exhaustion coming in the course of employment has been held to be an accident within the meaning of the law.' The opinion of Commissioner Fleitz goes into detail relative to the medical testimony, and it stated in conclusion that the testimony of the physicians would seem to meet all the requirements as to evidential value required by the appellate courts and constitutes a preponderance of the credible testimony of record. The board affirmed the referee's findings of fact, conclusions of law and award of compensation.

An article in Coal Age of August, 1929, states that one of the anthracite mines of Pennsylvania maintains a plant to heat the intake air in winter in order to be able to operate its downcast haulage shaft to advantage. This is a decidedly commendable practice and is one which could be used to advantage by many of our coal and metal mines. There is no question that the main haulage shaft should always be in fresh air to insure safe escape of workers at time of mine fire, hence all haulage shafts by which men pass into and out of the mine should by all means be on intake air; this is difficult to achieve in winter in some regions, however, and the practice of heating the intake air as described in the article mentioned is, therefore, a good one. There is a possible alternative for the above practice, at least in some mines, in that where there are available shafts or other openings to the surface, the main intake and main return may be through some shafts or openings not used for man travel or at least for man hoisting; and the main haulage shaft may be placed on a small split of pure intake air taken from the downcast shaft at some point underground after the intake air has had an opportunity to become slightly heated by coming in contact with underground strata. This is a practice now being adopted by several large-capacity metal mines, which in some instances are providing additional openings to make the plan effective.

The problem of cooling mine air has not been particularly well solved as regards either individual working places or the entire mine. In some regions where there are high summer daytime temperatures and underground strata temperatures between 70 and 85° F., it has been found advantageous to operate the main fan of some metal mines during the hot part of the day just long enough to clear away the fumes from blasting. In some of these mines the surface air with summer daytime

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temperature in excess of 90° F. increases the temperature of mine workings to such an extent as to make them decidedly uncomfortable, hence the main fan is operated only at blasting time and at night. Little or no progress has been made toward cooling individual working places, and the best method yet available undoubtedly is the supplying of adequate air movement or velocity at the point of actual work; the moving air had the natural cooling effect of evaporation induced by the passing or impinging air particles. In the DuPont Explosives Service Bulletin on auxiliary ventilation, issued in May, 1929, is a description of an inexpensive Venture blower which may be used to advantage in metal mines to provide a cooling air movement at or near the face.

In the foreign technical press there have been a number of references like the following, which was taken from the October, 1929, issue of the Mining Magazine of London:

> "Discussions have taken place on Dr. J. S. Haldane's proposals for avoiding silicosis by substituting dry mining methods for wet mining methods. Dr. Haldane holds that if the quartz dust could be mixed with shale dust the lungs would be enabled to work off the quartz dust which causes silicosis. He also stresses the fact that in deep mines water helps to raise the temperature, and when the temperature becomes too high miners become subject to heat strokes. Local opinion is that Dr. Haldane's scheme should be carefully investigated, but all experiments should be made under the strictest control. Mr. van Eyssen, consulting engineer to Messrs. Lewis and Marks, states that at the Lonely Mine, Rhodesia, many of the miners, both white and black, have worked there from the inception of the mine, yet not one of them is suffering from silicosis. This mine is a particularly dusty one.

To those who have spent any considerable amount of time studying the effect of dust in mine air on persons forced to breathe that air, it seems almost grotesque even to think of abandoning wet methods of mining, at least in so far as concerns the use of water while drilling, and in some mines while shoveling and before and after blasting. The attached item taken from the January 18, 1929, issue of Colliery Guardian, published in Great Britain, indicates that even coal-dust (held by most British and American dust authorities to be harmless when breathed by workers) causes not only illness but early death.

> A special verdict that Death was from pulmonary consumption caused by the inhalation of coal dust was returned at an inquest in London last week on George Albert Morgan (68), who was stated to have been a free miner, formerly owning a small mine at Brierley, in the Forest of Dean. The widow stated that her husband had been working underground in coal mines for 50 years. He was a free miner, having been granted the small mine because he had been born within two miles of Speech House, in the Forest of Dean. The mine, which he began working soon after the outbreak of war, had to be closed down about two years ago owing to failure of trade. Dr. R. M. Bronte, who made a post-mortem examination, said both lungs were jet black and very hard."

It would appear that if breathing air largely filled with coal dust (long held harmless and by some authorities to be helpful) brings about death, then it is manifestly foolhardy to advocate a mining policy in which decidedly large quantities of mineral dusts would be breathed by workers. Considered

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strictly on the basis of efficiency much of the rock in our metal mines could not be drilled dry with even any fair degree of efficiency with any drills yet fabricated; moreover, it is very doubtful if many of our better-informed miners would entertain even the probability of working in the super-dusty atmospheres so familiar in the so-called dry mining methods of the past. The attitude of a large part of the metal-mining industry on dust in metal mines is reflected very nicely in the following editorial which appeared in the Engineering and Mining Journal of January 26, 1929:

"Dust removal is a matter of dollars and cents, from whatever point one views it. To install a dust-collecting system costs something much or little, depending on the specific application and the quality of the job. The amount can be determined easily by soliciting bids. Estimates will vary widely, ranging from that of the tinsmith who looks upon the task as a mere matter of constructing housings, with perhaps a fan or two at some carelessly determined point, to that of the engineer who thoroughly understands the problem involved, with its various ramifications. Here it should be borne in mind that, as in any other installation intended for permanent use, work of good quality will be cheaper in the end. Some dust-collecting 'systems' have been worthless from the start.

"To do without a dust-collecting system will cost something also, wherever a plant has dusty air. This will be appreciated only when the operator comes to realize the ravages that dust can work. Perhaps it is because men have so long been looked upon as children of the dust, returning to it at the expiration of their days, that so many plant executives take dust as a matter of course. What is more natural than dust? We find it all about us. The wind blows it in our faces. The housewife is continually removing it from the furniture. So one should not be surprised if, in places, its presence in the air breathed by workmen from morning until night is ignored or considered lightly. Only when the condition becomes so obnoxious as to demand a remedy does it get attention.

"Wherein may dust, perhaps intrinsically worthless, cause a loss? That it must be injurious to health, if sufficient in quantity, every one knows. On this account alone it is safe to say that the day will come when in every State dust prevention will be prescribed by law as an ordinary precaution wherever men are engaged in work. The quicker industry is to adopt the remedy, the less onerous will be the legislation that must eventually be passed.

"Second, dust causes excessive labor turnover. No one prefers to work in dust and breathe it if another job can be found where the pay is as good and the conditions are pleasanter. Labor turnover and its effect on profits is a matter to which executives have given much attention. Dustiness in a plant will be found to be an influential factor. And even if dust does not actually drive a workman to seek employment elsewhere, it most certainly will make him less efficient by the annoyance and irritability it causes, in addition to its effect on his health in general. How illogical it is, moreover, in this day of the antifriction bearing and better lubrication practice - both devised to make machinery more efficient, to make it last longer, and

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to consume less power - to permit a condition of dustiness to continue, when dust tends to prevent the attainment of these three objectives. Dust in bearings is responsible for a goodly portion of the annual repair bills.

In short, dust causes a lot of trouble about a plant, directly and indirectly, and its removal is worth considering. Many a company outside of the mining industry would not think of operating without the adjunct of a dust-removal system. That the mine operator, so efficient underground and in his metallurgical work, so often lags behind his brother executives in other industries in this respect is indeed curious.

The agitation in Europe and South Africa against so-called "wet-mining methods" is due chiefly to the fact that use of water at or near faces in mines with strata temperature in excess of 80° F. brings about a high relative humidity condition which in still air about 80° F. is oppressive and in temperatures above 90° F. becomes almost unendurable as far as performing efficient work is concerned. The remedy, however, certainly can not be the substitution of dry drilling or dry handling of material instead of wet methods, as there is absolutely no question that excessive air dustiness, whether in coal or in metal mines, ultimately means the death of those forced to breathe it. It would appear from the following that even in South Africa, where most of the agitation for abandonment of wet methods has taken place, some of those engaged in mining are relatively well satisfied with present methods of air conditioning in the mines, at least in so far as prevention of silicosis is concerned:

> The Rand's gold mines are, in the central area especially, getting deeper and deeper, and there is no saying at present when or where the economic limit of depth will be reached. Already the West Sub. incline shaft of the Village Deep is fast approaching its final depth of 7,640 feet (1.4 mile) below the collar of the new Turf Shaft. The mean depth of stoping levels at the end of 1928 was 6,480 feet below shaft collar and the maximum depth of winzing below the 39th level was 7,360 feet. It will thus be seen that depths are fast being approached which will give rise to serious problems having no parallel on other mining fields to help in their solution. One of these problems is how the enormous pressures soon to be encountered are to be dealt with, which will probably mean the substitute of incline shafts for short verticals and cross cuts, shorter backs and narrow stopes worked on the panel system. The danger from rock bursts which, as it is, occur now and then and generally take their toll of life, will undoubtedly be increased and prove more formidable than the phthisis menace, which, though it has slain its thousands, has never yet closed down a mine, and thanks to the energetic and intensive policy of dust prevention in force is now well in hand, the dust content of mine air having been reduced to 0.8 milligram per cubic metre (the lowest average recorded so far) as against 5 milligrams in 1914.

The problem of providing suitable air for workers at faces where rock-strata temperatures are high, hence where the air is likely to be heated to or above the rock temperature and also to be highly humid because of naturally occurring water or water from wet drilling or other use, seems to be fairly well

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met at the properties of one large metal-mining company and one coal-mining company by coursing relatively large quantities of fresh air from the surface or providing local methods of giving fairly high velocity to the air in the vicinity of the workers. The method used by the metal mining companies is described in an interesting article on Ventilation of the Butte Mines, Anaconda Copper Mining Co., in the Mining Congress Journal of October, 1929; the last paragraph of this article reads as follows:

> "For future ventilation requirements, consideration has been given both to the possibilities of further improvement of present measures and of artificially cooling the mine air, as has been proposed and, to some extent, practiced in other places. Technically, there are no unsurmountable obstacles to be overcome in applying such a method to the Butte mines, but its use depends more upon economic factors. These, of course, vary at different properties. In tropical or semitropical climates the surface atmosphere is likely to be of relatively little value in improving ventilation conditions within the mine, because of the initial high temperature and humidity of the air entering the mine. In the Butte district, surface temperatures and humidity are decidedly low and offer much greater opportunity for reducing the mine temperatures. Cost of artificial cooling will, of course, depend to some extent upon the process used, and will also vary widely with conditions at different properties. In general application to extensive workings in the case of any problem of deep mines can hardly be other than a matter of very considerable expense. Under exceptionally severe conditions, such as may occur in dead ends during the development of lower levels, the use of artificial cooling may be warranted. For the main ventilation system in the Butte mines it seems, however, that reliance upon present methods will economically be most advisable, at least for some time to come."

The conditions encountered and methods used in the coal mine are given in the conclusions of an article in the July, 1929, issue of the Journal of The Chemical, Metallurgical, and Mining Society of South Africa:

> "The author concludes as follows: Other Practical Measures.— Of all the foregoing methods, the best results are obtained by doubling the air supply, since it is accompanied by a substantial increase in the air velocity, to which factor, as already mentioned, 67 per cent of the improvement in the KS reading is due. This influence of the velocity suggests the idea that, instead of doubling the volume of air, the velocity should be doubled by halving the cross sectional area of the airways, which would also reduce the transmission of heat from the rock by lessening the area of contact. The present practice is to make the galleries as large as possible, in order to reduce the frictional resistance to the flow of air; so that, in many cases, they could be reduced without impeding the haulage and without increasing the velocity beyond the permitted limit of 6 meters per sec. This practice has been adopted at the Sachsen Colliery for several years, with the result that the KS readings are maintained uniformly between 15 and 25, except occasionally at the face, where delays in stowing leave large empty spaces, and the air velocity is consequently low.

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"Though the increased resistance lowers the capacity of the fans, this can be balanced by the smaller air losses through short-circuiting of the current. These losses are mainly due to leakage and the opening of the air doors, on the one hand, and to loose stowage on the other. Leaving the air doors open may cause the air temperature to fluctuate 6°C in a few minutes, when new doors are not properly tight, and may leak to the extent of 10 per cent of the total air current, or even more when the current is large, in which case several doors should be arranged in succession. Other causes of short-circuiting are cavities in the goaf stowage and resulting fissures in the rock; in addition to which, the formation of CO_2 (by oxidation) in the goaf raises the temperature of the air passing therethrough. It has been found by repeated measurements that the total loss of ventilating air through short-circuiting may amount to as much as 25 per cent of the total, despite all preventive measures; and some pits report a loss of 60 per cent.

"The increased resistance due to lessened sectional area can be counteracted by smoothing the walls. For this purpose, some of the intake and return airways in the Sachsen pit have been lined with boards, thereby reducing the resistance in a considerable degree and increasing the volume of air supplied per minute by about 25 per cent, with the same consumption of power by the fan. Packing sawdust behind the boards reduces the transmission of heat from the rock, thus lowering the air temperature and improving the Katathermometer reading. The reduction in area of the intake airways can also be counteracted by dividing or widening the return ways; and where these latter form the sole haulage roads, the increased area lessens the resistance to the augmented volume of the return air (about 10 per cent above that of the intake, owing to the higher temperature and the accession of gas from the rock). At the same time the larger rock surface exposed and the formation of CO_2 from scattered coal results in a progressive rise in air temperature to the upcast; whilst, on the other hand, the temperature in the intake airways is reduced by about 4°C through the absence of CO_2 from scattered coal, and short-circuiting is lessened because doors can be set up anywhere without interfering with the haulage. The increased temperature of the return air improves the draught in the upcast shaft and therefore increases the ventilating current.

In opening up a deep pit, the development work should be carried on in a way calculated to enable the volume and velocity of the intake current to be increased, and the heat given out by the rock and oxidation kept down as much as possible by concentrating the work, reducing the number and length of the intake airways, and hauling the coal through the return ways. The air may be supplied to several districts from a main staple shaft, being split as near to the working places as possible, so that the rise in temperature is minimised. Development should be pursued in accordance with a time plan, with a view to minimising the heating effect of newly exposed rock. Places supplied with separate ventilation should be worked by a concentration of effort and only during the winter, the air brattices being insulated and the return taken to the main return ways by the shortest route; and in no case should two adjacent headings be driven at a time. Finally, development work should not be undertaken sooner than is necessary, since every needlessly exposed square yard of rock surface means increased air temperature.

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"The effect of rock temperature and heat of oxidation being greatest at the face, and the air velocity of the current therefore reduced, special attention must be devoted to minimum sectional area, short face length, and compact stowage. Not more than 30 men per shift should be employed in each ventilation section, in order to minimise splitting. Working toward home is advisable, in order to keep the air out of the goaf and to cool the standing coal; and loading direct into tubs is preferable to the use of face conveyors, the latter giving increased opportunity for oxidation and transmission of heat from the coal.

"The foregoing measures have been largely adopted in the Sachsen pit, where they have resulted in improving the cooling action of the ventilating current and increased output; whilst the men who formerly worked in a naked condition and bathed in perspiration now wear clothing.— F. Jansen, Colliery Guardian, Oct. 14, 1917. (J. C.).

That the problem of "conditioning" the air of mine working places is a complex one and that a suitable solution in one region may not necessarily be applicable to another or other regions is brought out by the following excerpt from the April, 1929, issue of Industrial Hygiene:

"The observations on atmospheric conditions in coal mines in India recorded in this paper are of great interest to industrial hygiene. Generally the climate, especially in the hot season, is such in India that it is a relief to go below ground; and the coal face, the furtherest point from incoming air, is the coolest place. Nevertheless, conditions entirely unfavorable to white men are quite usual, and a wet bulb temperature of 85° F. is common, with the air practically still. In one place at 99° F. wet bulb, work had been going on regularly for months without obvious ill effect to the workers. Keeping in mind that 80°F wet bulb has been fixed as the upper limit for active work in Britain, such observations indicate that an Indian must be acclimatized to heat quite differently from Europeans. His low "minimal metabolism" and pigmented skin may be important factors. He dislikes a breeze and prefers 75°F. to 50°F. for work; and one group objected to leaving 88°F. with 98 per cent humidity for 20 degrees lower. He works irregularly; he may work steadily for an hour and then rest for fifteen minutes in a cooler place. Apparently effective temperature scales must be constructed afresh for such members of the human race. —E.L.C.

HEALTH IN AND AROUND METAL MINES

Adequate ventilation has long been known to be the most important step in any movement toward the improvement of the health of metal miners, and the following editorial taken from the Engineering and Mining Journal of Dec. 8, 1928, is a vigorous expression of the attitude of the leading metal mining journals on this subject:

"The fine record of some mining companies in improved health conditions for underground and surface workers contrasts with the attitude of the majority - that it were best to ignore the subject rather than to invite attention to what might be judged as an unsatisfactory condition. Good ventilation underground is impracticable; the conditioning of air

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is too costly; dust control is a fad; the spread of communicable diseases is inevitable - these are the arguments sometimes advanced in excuse for a continuation of conditions the effect of which is diminished output, failing morale, suffering, and loss. For hundreds of years the mining industries of the world have performed the ostrich act of burying the head in desert sand to avoid a candid recognition of what is obvious to the world at large. Underground mining is hazardous, but reports and statistics have proved that tremendous advances have been made in recent years in the reduction of accidents. This fine showing should be used as an inspiration and as an incentive for a mass attack on the problems of healthful conditions in mine and mill, by the provision of adequate lighting and ventilation, atmospheric temperature and moisture control, dust collection, medical examination, and hospital service.

"The old conception of requirements in the safeguarding of health was to have a company doctor, supplemented, perhaps, by a company hospital for curing the ills of employees and their families at little or no cost to the individuals principally concerned. Highly progressive companies sometimes maintained a dentist as well. More recently the safety engineer has come to be as important as the doctor. The prevention of accidents and the maintenance of good health are fundamental to efficient management and constitute a field in which the company doctor, the safety engineer, and the company officials, as well, should cooperate.

"The mining industries of the United States will do well to support the proposed National Institute of Health and encourage those researches on individual industry problems that have so potent an influence on the health of the country as a whole. Technical and economic progress in recent years has been due in large part to the commendable efforts to made to safeguard the worker; but much more needs to be done before the metal mining industry can be given a clean bill of health. The insurance of health and health insurance are not one and the same. Responsibility for the outcome of unhealthful conditions can not be evaded by the payment of premiums. Better to face conditions in their reality, meet the monetary loss, and determine to reduce the hazard, as has been done with accidents."

In connection with the numerous ills due or thought to be due to high-temperature air in mines, it appears that the boils which have been found to affect considerable numbers of miners (metal as well as coal) are now suspected of of being caused by high-temperature air or possibly high-temperature water. The following paragraphs taken from the July 19, 1929, issue of the Iron and Coal Trades Review bring up some conditions which should be investigated in the United States as well as in Great Britain:

"Mr. L. Holland said that, whilst he had nothing to say with regard to the physical side, on the practical side, whilst dealing with fires, he had noticed that some of the workers suffered from intense irritation of the skin. He wondered whether that was due to the loss of water or the loss of salt.

"Dr. Hancock said he had noticed that certain districts where sweating was common, irritation of the skin did occur, and he had met with instances of boils which were a source of irritation. He had also

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noticed in those cases where boils occurred that the air conditions were not what they might be. The air was not as pure as it should be, and when one had heat, humidity, and poor air, there was a strong tendency to this incidence of boils. It was a question which needed investigation. As to whether the trouble was due to loss of water, or salt, or the air conditions, he could not say.

Boils have caused considerable trouble in some of the mines of Nevada and other states and usually the trouble has occurred in mines which are hot and wet.

The following data taken from an article in the Mining Congress Journal for November, 1929, give information concerning a health clinic which has been functioning with remarkable success in the Picher, Okla., mining region, where miner's consumption and other diseases of miners are decidedly prevalent. There should be many such clinics in our mining communities:

Along with the inauguration of the accident prevention work, a study of health conditions was begun by the United States Bureau of Mines. X-ray examinations revealed the widespread prevalence of silicosis and tuberculosis among the miners, many of whom had worked in the dusty mines of the Joplin District. The outcome of this study was a cooperative agreement reached in the early spring of 1927 between the Bureau of Mines, the Metropolitan Life Insurance Co., and the Tri-State Zinc and Lead Ore Producers Association, for the establishment of a well-equipped clinic at Picher, for the free examination of miners and other employees and their families, and also of applicants for employment.

Since the opening of the clinic, June 1, 1927, it has become increasingly evident that it is one of the most valuable assets to the work of accident prevention. It is obvious that illness and physical disability are apt to be fruitful causes of accident. In the first seven months of the operation of the clinic, 9,803 persons, including over 400 women and children, were given complete physical examinations, and the number being examined continues at about the same rate. The safety engineers have cooperated in every way possible to induce the men and their families to make use of the clinic, and the results have been very gratifying.

Following his examination, each man is given a clinic card containing his photograph, physical rating, and instruction as to when to report for reexamination. He is given proper advice, and, in certain cases, treatment. As a result, many men have been taught to take proper care of their health, many have left the mines for open-air employment, and others have been transferred to jobs more suitable to their physical condition.

It has not been the policy of companies to discharge a man on account of low physical rating, but rather to assist him to improve his condition. An applicant for employment, however, is asked by most companies to show his clinic card, and any one with a serious infirmity or a contagious disease is not employed. This precaution is a very valuable protection not only to the company but to the employees. Most of the miners have come to realize the value of the clinic to them and do not hesitate to make use of it.

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CONCLUSION

Metal-mining people have never been more inclined toward systematic ventilation of their properties than now; this is manifested in numerous activities, not only of individual companies but also of organizations concerned with the improvement of conditions affecting ventilation of metal mines. One of these manifestations is the work of the American Mining Congress Committee on a Code for the Ventilation of Metal Mines, which is now engaged in "rounding out" the proposed code or standard.

Numerous inquiries and discussions concerning various details entering into the ventilation of metal mines have been made; some of these are; What is the correct type of main fan or of auxiliary fan? What is a good type of ventilation door, fire door, or ventilation regulator? What is the most effective lining of a main air-carrying shaft? Should the main fan be a blower or should it be used as an exhaust unit? Should the fan be placed so as to allow ready reversing of air direction? These and a large number of additional questions have been discussed, although a definite answer has not always been forthcoming. For instance, there is a wide difference of opinion as to the construction of a satisfactory type of fire door - one which will resist fire, will not warp or sag, will close tightly and leak little, will not decay or rust or otherwise disintegrate, and can be used from day to day if necessary.

In the Iron and Coal Trades Review, issue of March 22, 1929, a short article entitled "Life-Saving in Colliery Explosions and Fires," discusses some of the advantages of the use of doors and particularly of emergency doors on intake air courses to be operated at time of fires for the protection of employees who may be on the interior of the mine and on the return air side of the fire or explosion. There is absolutely no question that well-placed doors may be utilized to advantage in saving employees in both coal and metal mines at time of fires and probably to a lesser extent in explosions. The following paragraph taken from the article in the Iron and Coal Trades Review summarizes the points claimed by the principal proponent of the use of doors.

> (1) That the men inby will make use of the life-saving door when the need arises; (2) that when the life-saving door has been shut, and even if the fan is not stopped or 'slowed,' the air in the return will not become irrespirable by leakage of smoke into it, before the men at the face have had time to come out; (3) that facilities for reversal of the ventilation are not an effective safeguard; (4) that providing materials for erecting a barricade is likewise not an effective safeguard; (5) that the specified position--in the intake, just outby of the first branch road to the face--will rarely be in unsettled ground; (6) that it will be practicable to keep the door--in that position--reasonably air-tight, and that even a very leaky door will be far better than no door; (7) that the door would have been an effective safeguard to avert each of the ten worst disasters in Great Britain in recent years, which have been described in the Paper and discussions, and in which 990 men and boys were in grave peril, of whom 481 were killed by smoke from a fire in the intake.

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THE GROWING ADOPTION OF MECHANICAL VENTILATION IN METAL MINES

Metal mines are adopting mechanical ventilation much more extensively than in the past, and this movement has naturally been accompanied by an increased use of such so-called coal-mine devices or adjuncts as overcasts, undercasts, regulators, splits, doors, brattices, and even curtains for air deflection. Thoughtful and far-seeing metal-mine operators are now providing and maintaining air courses not only for intake but also return or used air, even sinking shafts, driving raises, drifts, etc., wholly for ventilation. Sealing of abandoned workings is being done in some mines to conserve air supply or to prevent air vitiation.

Although many mines hold main haulage shafts on return air, there are numerous instances where the far safer system of holding main haulage on intake or at least fresh air is maintained. In general, present-day fan installations at metal mines allow reversing the direction of air currents, but unfortunately only a small percentage of the mines install doors in such manner as to be able to take advantage of this reversing feature if it is needed. Some of the wide-awake metal-mine operators are using smooth-lined, fireproofed main air-carrying shafts, thus reducing fan power consumption and at the same time providing the most effective type of fire insurance. Other mines are manipulating the air currents (where they are thoroughly under control- this means of fan, doors, overcasts, etc.) to prevent fungus growth, or even to kill fungus where it gets a start. In fact numerous metal-mining companies are now taking advantage of the almost limitless benefits obtainable in an up-to-date mine from a well-installed and well maintained ventilation plant.

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